# REACTION FORCE ISOLATION SYSTEM

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## FIELD OF THE INVENTION

The present invention relates generally to motor driven positioning systems, and more particularly, to a method and apparatus for positioning and aligning a reticle or wafer in a photolithography system with a motor and isolating the system from reaction forces from the motor.

## BACKGROUND OF THE INVENTION

Various support and positioning structures are available for positioning an article for precision processing. For example, in semiconductor manufacturing, a wafer and reticle are precisely positioned with respect to a photolithography apparatus. Planar or linear motors are typically used to position and align the reticle and wafer for exposure in the photolithography apparatus. Conventional planar motors used in semiconductor manufacturing are disclosed in U.S. Patent Nos. 4,535,278 and 4,555,650, for example.

A semiconductor device is typically produced by overlaying or superimposing a plurality of layers of circuit patterns on the wafer. The circuit pattern is first formed in a reticle and transferred into a surface layer of the wafer through photolithography. The layers of circuit patterns must be precisely aligned with one another during processing. This requires precise alignment of the wafer and reticle during the photolithography process. One source of alignment error is vibration of the structures within the photolithography system. The reaction forces between the moving portion and fixed portion of the motor are often a source of vibrations in the system.

As the circuit density of integrated circuits increases and feature size decreases, alignment errors must be further reduced or eliminated. Precise alignment of the overlays is imperative for high resolution semiconductor manufacturing.

There is, therefore, a need for a structure which isolates the vibrations induced by reaction forces generated by a motor to reduce or eliminate misalignment caused by the vibrations.

## SUMMARY OF THE INVENTION

The present invention provides a structure for isolating vibrations induced by reaction forces generated in a motor used to position a reticle. A fixed portion of the motor, which is subject to reaction forces, is structurally isolated from the rest of the system in which the motor is operating.

An exposure apparatus of the present invention generally includes an optical system for imaging a pattern formed in a reticle onto an article, a reticle stage for supporting the reticle, and a motor for positioning the reticle stage and reticle relative to the optical system. The motor has a first portion and a second portion. The first portion is connected to the reticle stage and movable relative to the second portion. The apparatus further includes a vibration isolation device configured to isolate vibration from reaction forces between the first and second motor portions.

The vibration isolation device may include structure which is structurally independent of the first portion of the motor and connected to the ground, for example. The vibration isolation device may further include a bearing for supporting the second portion of the motor to allow it to move in a direction opposite the first portion of the motor to counteract the reaction forces.

A flywheel may also be connected to the second portion of the motor to absorb rotational reaction forces created between the first and second motor portions.

In one embodiment, the exposure apparatus comprises a wafer stage and a wafer vibration isolation device configured for isolating vibration from reaction forces between a magnet array and coil array of a motor driving the wafer stage. The motor used to drive the reticle stage or wafer stage may be a planar motor or a linear motor.

A method of the present invention is for directing reaction forces created between first and second motor portions away from the first motor portion. The first motor portion is connected to a reticle stage for positioning a reticle relative to an optical system. The method

comprises structurally isolating the second motor portion from the first motor portion to isolate vibration induced by the reaction forces created between the first and second motor portions.

The above is a brief description of some deficiencies in the prior art and advantages of the present invention. Other features, advantages, and embodiments of the invention will be apparent to those skilled in the art from the following description, drawings, and claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic of a projection exposure apparatus with a reaction force isolation system of the present invention.

Fig. 2 is an exploded view of one embodiment of a planar motor used in the exposure system of Fig. 1;

Fig. 3 is a schematic of a projection exposure apparatus with a second embodiment of the reaction force isolation system of Fig. 1;

Fig. 4 is a schematic of a projection exposure apparatus with a third embodiment of the reaction force isolation system of Fig 1;

Fig. 5 is a schematic of a projection exposure apparatus with a fourth embodiment of the reaction force isolation system of Fig. 1;

Fig. 6 is a schematic of a projection exposure apparatus with a fifth embodiment of the reaction force isolation system of Fig. 1;

Fig. 7 is partial schematic of a projection exposure apparatus with a sixth embodiment of the reaction force isolation system of Fig. 1;

Fig. 8a is a side view of a flywheel and rotary motor attached to a coil array of the projection exposure apparatus of Fig. 3; and

Fig. 8b is a perspective of the flywheel, rotary motor, and coil array of Fig. 8a.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

## DESCRIPTION OF THE INVENTION

Referring now to the drawings, and first to Fig. 1, a projection exposure apparatus, generally indicated at 10, is shown. To illustrate the principles of the present invention, the isolation of vibrations induced by reaction forces generated by a motor is described in reference to a scanning-type photolithography system for substrate processing. However, it is to be understood that the present invention may be easily adapted for use in other types of exposure systems for substrate processing (e.g., projection-type photolithography system or electron-beam (EB) photolithography system disclosed in U.S. Patent No. 5,773,837) or other types of systems (e.g., pattern position measurement system disclosed in U.S. Patent No. 5,539,521, wafer inspection equipment, machine tools, microscope) for processing other articles in which the reduction of vibrations induced by reaction forces generated by a motor is desirable.

Fig. 1 is a schematic representation of a scanning-type exposure system 10 for processing a substrate, such as a wafer 12. In an illumination system 14, light beams emitted from an extra-high pressure mercury lamp are converged, collimated, and filtered into substantially parallel light beams having a wavelength needed for a desired exposure (e.g., exposure of photoresist on the wafer 12). In place of the mercury lamp, an excimer laser (Krf, Arf, or F2) can also be used. The light beams from the illumination system 14 illuminate a pattern formed in a reticle 16 which is mounted on a reticle stage 18. The reticle stage 18 includes an opening (not shown) to allow the light beams to pass through the stage. The stage may also be configured to support or retain the reticle along only one side of the reticle, for example. The light beams penetrating the reticle 16 are projected on the wafer 12 via projection optics (lens) 24. The reticle stage 18 is movable in several degrees of freedom (e.g., three to six) by an actuator 31 which may be a linear or planar motor as further described below. The reticle stage 18 is supported by bearings (not shown) on a reticle stage frame 40. These bearings may be air bearings, for example. An interferometer 34 is mounted on the reticle stage frame 40 and interacts with a mirror 35 to measure the position of the reticle 16 and provide a signal to a control system 22, as is well known by those skilled in the art. The control system 22 operates in conjunction with a drive

system 20 and the motor 31 to control the position of the reticle 16. The drive system 20 provides the user with information relating to the position of the reticle 16.

The wafer 12 is positioned under the projection optics 24 and preferably held by vacuum suction on a wafer holder (not shown) which is supported on a wafer stage 26. The wafer stage 26 is structured so that it can be moved in several degrees of freedom (e.g., three to six) by a planar motor 30 under precision control by a driver 32 and the system controller 22, to position the wafer 12 at a desired position and orientation relative to the projection optics 24. The driver 32 provides the user with information relating to X, Y, and Z positions as well as angular positions of the wafer 12. For precise positional information, an interferometer 36 and a mirror 37 are provided to detect the actual position of the wafer 12. The signal from the interferometer 36 is fed to the control system 22 which acts with the driver 32 and motor 30 to control the position of the wafer 12.

In operation, the light beams from the illumination system 14 pass through the reticle 16 and expose photoresist on the wafer 12, which is supported and scanned using the wafer stage 26 driven by the motor 30. In the scanning-type exposure apparatus, the reticle 16 and the wafer 12 are scanned and exposed synchronously (in accordance with the image reduction in place) with respect to an illumination area defined by a slit having a predetermined geometry (e.g., a rectangular, hexagonal, trapezoidal or arc shaped slit). This allows a pattern larger than the slit-like illumination area to be transferred to a shot area on the wafer 12. After the first shot area has been completed, the wafer 12 is stepped by the motor 30 to position the following shot area to a scanning start position. This system of repeating the stepping and scanning exposure is called a step-and-scan system. The scan-type exposure method is especially useful for imaging large reticle patterns or large image fields on the wafer 12, as the exposure area of the reticle 16 and the image field on the wafer are effectively enlarged by the scanning process.

It is again noted that the configuration of the exposure system 10 described above generally corresponds to a step-and-scan exposure system that is well known in the art. Further details of the components within a scanning-type exposure apparatus may be referenced from U.S. Patent Nos. 5,477,304 and 5,715,037, which are incorporated herein by reference in their entirety. It is to be understood that the present invention is not limited to wafer processing systems, or to step-and-scan exposure systems for wafer processing. The general reference to a step-and-scan exposure system is purely for illustrating an embodiment of an environment in

which the concept of isolation of motor reaction forces to reduce system vibration may be advantageously adopted.

The components of the motor 30 used to move the wafer stage 26, are schematically illustrated in Fig. 2. The motor 30 is a planar motor comprising an array of magnets (first motor portion) 56 and an array of coils (second motor portion) 50 having a plurality of coils 55 which are electrically energized under control of the driver 32 (Figs. 1 and 2). A plate 52 is positioned above the coil array 50 to support the wafer stage 26. The plate 52 is preferably made of non-magnetic materials, such as carbon fiber composites, plastics, ceramics including Zerodur ceramics, Al2O3 ceramics, and other suitable materials which do not impair the magnetic flux of the magnets. The current distribution of the coil array 50 interacts with a permanent magnetic field of the magnet array 56 to cause a force between the magnet array and coil array. The interaction of the magnetic field and the current distribution permits the magnet array 56 to move with respect to the coil array 50 in at least three, and preferably six degrees of freedom.

The motor 31 used to position the reticle stage 18 is similar to the motor 30 described above. The planar motor includes a magnet array 49 and a coil array 47 positioned adjacent to the magnet array and operable to interact with magnetic fields of the magnet array to move the reticle stage 18 (Fig. 1). The coil array 47 is attached to a lower surface of reticle coil array frame 41 and the magnet array is attached to an upper surface of the reticle stage 18, surrounding the reticle 16.

For simplicity, many details of the planar motor are omitted from Fig. 2, as they alone do not constitute a part of the present invention. The planar motor may be a motor as described in pending U.S. Patent Application Serial Nos. 09/192,813, by A. Hazelton et al., filed November 16, 1998, 09/168,694, by A. Hazelton et al. filed on October 5, 1998, and 09/135,624, by A. Hazelton, filed August 17, 1999, for example. Structural details and operational principles of planar motors are also disclosed in U.S. Patent Nos. 4,535,278 and 4,555,650. Each of the above patents and patent applications are incorporated herein by reference in their entirety. One or both of the motors 30, 31 may also be a linear motor as described in U.S. Patent Application Serial No. 09/219,545, by A. Hazelton et al., filed December 22, 1998, for example. It is to be understood that the type of motor used to position either the reticle stage 18 or the wafer stage 26 may be different than those described herein without departing from the scope of the invention.

Both motors 30, 31 cause a reaction force acting on the coil arrays 47, 50. As further described below, the reaction force isolation system of the present invention isolates these reaction forces from the rest of the exposure apparatus.

The motors 30, 31 include magnet arrays 49, 56 which are attached to the reticle stage 18 and wafer stage 26, respectively and are free to move with the stages relative to the coil arrays 47, 50 (Fig. 1). This moving magnet embodiment is generally preferred over a moving coil arrangement when used in positioning devices, because the magnet arrays do not require electrical current connections or cooling. However, it is to be understood that the coil arrays 47, 50 may also be attached to the stages 18, 26 and movable relative to fixed magnet arrays.

In the embodiment shown in Fig. 1, the illumination system 14, the reticle stage 18, and the projection optics 24 are separately supported by frames 38, 40, and 42, respectively. The frames 38, 40, 42 are coupled to the ground (or other surface on which the overall exposure system is supported) through isolation system 60 and supports 48. The projection optics frame 42 is mounted on the support 48 using the damping means 60. By providing the damping means 60 to couple the frames 38, 40, and 42 to the ground, any vibration that may be induced by the reaction forces through the ground is isolated from the rest of the exposure system 10. The damping means 60 therefore, prevents the vibration of the ground from transmitting to the projection optics 24, the illumination system 14, the reticle 16, or the wafer 12. The damping means 60 may include air or oil dampers, voice coil motors, or actuators, for example. Preferably, the damping means 60 includes an actuator (schematically shown at 61) to maintain the projection optics frame 42 and the reticle coil array frame 41 level and prevent misalignment of the optical axes of the projection optics 24 and the illumination system 14. The actuator 30, 31 and positional feedback scheme needed to achieve the leveling objective may be implemented using systems which are well known by those skilled in this art. The illumination system and reticle stage frames 38, 40 are mounted on the projection optics frame 42 to avoid the need for additional damping means, since the damping means 60 isolates the combined frames 38, 40 and 42. However, the illumination system and reticle stage frames 38, 40 may also be individually coupled with ground.

The reticle stage 18 and wafer stage 26 are each supported by bearings (e.g., air bearings) on the reticle stage frame 40 and the support plate 52, respectively. The reticle stage frame 40 and the support plate 52 are both supported by the projection optics frame 42. The coil arrays

47, 50 are separately and rigidly coupled to the ground by fixed stands (vibration isolation devices) 63 and 62, respectively. When reaction forces are created between the coil arrays 47, 50 and the magnet arrays 49, 56, the reaction forces push against the ground. Because of the large mass of the ground, there is very little movement of the coil arrays 47, 50 due to the reaction forces. Since the reaction forces do not act on the frames 38, 40, and 42, vibration of the stages 18, 26, illumination system 14 and lens 24 due to reaction forces between the portions of the motor are substantially eliminated.

In a second embodiment of the present invention, generally indicated at 65 and shown in Fig. 3, the support plate 52 and the coil array 50 of the wafer motor 30 are supported by the projection optics frame 42. The plate 52 is attached to mid sections of vertical members 70 which depend from a horizontal member 45 of the projection optics frame 42. A horizontal support platform 72 is attached to opposite ends of the vertical members 70. The coil array 50 rides on a vibration isolation device comprising bearings 74 (e.g., air bearing or ball bearings) which move upon the horizontal support platform 72. In this embodiment, the reaction forces cause the coil array 50 to move sideways on the bearings 74, thus absorbing the reaction forces with its inertia. The reaction forces are absorbed by this inertia, since the reaction forces are very small compared to the weight of the system that comprises the projection optics 24, wafer stage 26, reticle stage 18, and illumination system 14. The invention of Fig. 3 uses the principle of momentum conservation, so the center of gravity of the system 10 does not shift according to the position of the wafer stage 26. Therefore the damping means 60 of this invention do not require an actuator 61 as provided in the first embodiment shown in Fig. 1.

Similar to the wafer stage 26 described above, the reticle stage 18 is supported by bearings (not shown) on a support plate 82 which is connected to the reticle stage frame 40. The coil array 47 rides on bearings 84 (e.g., air bearing or ball bearings) on the reticle stage frame 40. The magnet array 49 is mounted on a lower surface 88 of the reticle stage 18. The coil array 47 is positioned adjacent to the magnet array 49 to interact with magnetic fields of the magnet array to move the reticle stage 18. The reaction forces cause the coil array 47 to move on the bearings 84, thus absorbing the reaction forces with its inertia. As the reticle stage 18 is forced in one direction, the coil array 47 freely moves in the opposite direction due to the conversation of momentum principle. Thus, the force is transferred to the inertia of the moving coil array 47 and not to the body of the exposure apparatus.

A flywheel, indicated schematically at 90 in Fig. 3, may also be attached to one or both of the coil arrays 47, 50 to absorb torsional forces and prevent rotation of the coil array. A rotary motor 110 is preferably interposed between the coil array 47, 50 and the flywheel 90 to rotate the flywheel and counteract the torsional forces (Figs. 3, 8a, and 8b). The angular momentum on the coil array 47, 50 with the rotary motor 110 and flywheel 90 attached to the coil array can be calculated as:

$$\int T dt = (J_c + J_f)\omega_c + J_f\omega_{cf}$$
$$= 0 \text{ (for sufficiently large t)}$$

where:

$T$ = Torque on coil array;

$J_c$ = mass moment of inertia of coil array;

$J_f$ = mass moment of inertia of flywheel;

$\omega_c$ = angular velocity of coil array; and

$\omega_{cf}$ = angular velocity of rotary motor (which is equal to the angular velocity of the coil array relative to the flywheel).

The rotary motor 110 thus rotates at a speed $\omega_{cf}$ to rotate the flywheel 90 at an appropriate speed to compensate for the torsional forces on the coil array 47, 50 and prevent rotation of the coil array. The angular velocity of the rotary motor $\omega_{cf}$ should be sufficiently large so that the angular velocity of the coil array $\omega_c$ is small. The rotary motor 110 is preferably driven by a controller (not shown) which monitors the angular rotation of the coil array 47, 50.

In a third embodiment, generally indicated at 95 and shown in Fig. 4, the plate 52 is supported on support posts 54 which project through clearance holes in the coil array 50. The support posts 54 rest on a base 58 to shorten the length of the posts and prevent the posts from bending. The plate 52 and the support posts 54 may be formed separately or formed as a unitary structure. The base 58 is coupled to the ground by damping means 60, such as air or oil dampers, voice coil motors, actuators, or other known vibration isolation systems. The illumination system, reticle stage and projection optics frames 38', 40', and 42' may also be coupled to the ground by similar damping means. The coil array 50 is separately and rigidly

coupled to the ground by fixed stands (vibration isolation device) 62. In this embodiment, when reaction forces are created between the coil array 50 and the wafer stage 26, the reaction forces push against the ground. Because of the large mass of the ground, there is very little movement of the coil array 50 from the reaction forces. By providing damping means 60 to couple the base 58 and the illumination system, reticle stage, and projection optics frames 38', 40' and 42' to the ground, any vibration that may be induced by the reaction forces through the ground is isolated from the rest of the exposure apparatus.

A fourth embodiment, generally indicated at 98, is shown in Fig. 5. The fourth embodiment is similar to the third embodiment 95, except that instead of rigidly coupling the coil array 50 to the ground, a bearing coupling (vibration isolation device) 64 is used. The bearing coupling may be a planar (X, Y, and Theta Z) journal bearing 64 positioned at the end of supports 66 coupled to the coil array 50, for example. Ball bearings or air bearings may also be used. When reaction forces are created between the magnet array 56 and the coil array 50, the wafer stage 26 and the coil array move in opposite directions and the coil array absorbs the reaction forces. The mass of the coil array 50 is typically substantially larger than that of the wafer stage 26. Consequently, in accordance with conservation of momentum, the movement of the coil array 50 caused by the reaction force is typically substantially smaller than the movement of the wafer stage 26 under the same reaction force. It is to be understood that in the embodiment of Fig. 5, the damping means 60 may be omitted if the bearing support 64, 66 can effectively isolate all reaction forces that may induce vibrations in the rest of the exposure apparatus.

In a fifth embodiment of the present invention generally indicated at 102 and illustrated in Fig. 6, the coil array 50 is rigidly supported on the ground by supports (vibration isolation device) 62. In this embodiment, instead of supporting the plate 52 of the planar motor 30 on support posts 54 on the base 58, as was done in the earlier embodiment (shown in Fig. 4), the plate 52 is supported by the projection optics frame 42'. The plate 52 is preferably formed with a thick honeycomb structure or other type of reinforced structure to prevent it from bending. The projection optics frame 42' is isolated from vibration transmitted through the ground by a damping means 60.

Fig. 7 shows a sixth embodiment, generally indicated at 104. The motor 30 includes a cooling platform 76 which is supported by a horizontal support platform 72. The cooling

platform 76 includes conduits 78 through which coolant 77 can pass through. Alternatively, Peltier cooling or ventilating air cooling may be deployed. The wafer stage plate 52 is supported on stands 80 which are supported on the cooling platform 76. The cooling platform 76 provides a support surface on which the coil array 50 rests on bearings 74. The wafer stage 26 further includes a leveling stage 83 which positions the wafer 12 in three additional degrees of freedom. The leveling stage 83 has at least two actuators 94 (e.g., voice coil motors) which actuate in the direction of axis A of projection optics 24 in accordance with focus sensors 92a and 92b. One focus sensor 92a emits a focusing beam to the wafer 12 and the other focus sensor 92b receives the reflected beam from the wafer 12. The leveling stage 83 adjusts the focal plane of the projection optics 24 to align with the surface of the wafer 12. It is preferable that the leveling stage 83 be structurally isolated (without mechanical contact) from the wafer stage 26 so that vibration of the wafer stage 26 (e.g., caused by the air bearing) may be isolated. Additionally, a cooling system such as described in U.S. Patent Application Serial No. 09/259,465, by A. Hazelton et al., filed February 26, 1999, may be used as the above described cooling system to cool the coil array 50 of the motor 30.

It is to be understood that the vibration isolation devices shown in the third, fourth, fifth, and sixth embodiments to isolate vibration from the wafer stage 26, may also be incorporated in the reticle stage 18, as described above for the first and second embodiments. Further, any combination of vibration isolation devices may be used for the reticle and wafer stages 18, 26, or a vibration isolation device may be used only for the reticle stage or the wafer stage, for example.

While the invention has been described with respect to the described embodiments in accordance therewith, it will be apparent to those skilled in the art that various modifications and improvements may be made without departing from the scope and spirit of the invention. For example, in the above embodiments of Figs. 4, 5, and 6, the illumination system, reticle stage, and projection optics frames 38, 40, and 42 are separately coupled to the ground. Alternatively, the illumination system and reticle stage frames 38 and 40 may be mounted on the projection optics frame 42 without damping means as in Figs. 1 and 3. Conversely, the illumination system, reticle stage, and projection optics frames 38, 40 and 42 in the embodiments of Figs. 1 and 3 may be separately supported on damping means as in Figs. 4, 5, and 6. Additionally, various combinations of damping means and bearing support may be deployed to provide the

reaction force isolation function, or to provide redundancy in such function. Further, the present invention may be adopted in other types of exposure apparatus and other types of processing systems in which precision positioning utilizing a motor is desired. While the described embodiments illustrate planar motors used in an X-Y plane, planar motors used in other orientations and more or less dimensions may be implemented or linear motors may be used with the present invention.

The photolithography system according to the present imbodiment is also applicable to a step-and-repeat type photolithography system that exposes a mask pattern while a mask and a substrate are stationary and the substrate is moved in step in succession. Alternatively, the photolithography system according to the present invention may be used for a proxomity photolithography system that exposes a mask pattern by closely locating a mask and a substrate without the use of e projection optical system.

The light source for the photolithography system of the present invention is not limited to the use of g-line (436nm), i-line (365nm), KrF excimer laser (248nm), ArF excimer laser (193nm) and $F_2$ laser (157nm). Charged particle beams such as x-rays and electron beams can be used. for instance, in the case where an electron beam is used, thermionic emission type lanthanum hexaboride ($LaB_6$) or tantalum (ta) can be used as an electron gun. Furthermore, in the case where an electron beam is used, the structure could be such that either a mask is used or a pattern can be directly formed on a substrate without the use of a mask.

When far ultra-violet rays are used, such as those emitted by the excimer laser, the glass material of the projection optical system is preferably quartz or fluorite glass. These materials are well suited for the transmission of far ultra-violet rays. Further, when the projection optical system employs an $F_2$ laser or x-ray, the optical alignment chosen should be either catadioptric or refractive (and include a reflective reticle.) The preferred projection optical system for electron beams includes electron lenses and deflectors; and the optical path for electron beams should be in a vacuum. In any instance, the magnification for projection optical system is not limited to a reduction system, but can include a 1x or higher magnification system as well.

The assembly of the photolithography system described herein requires the integration of various described subsystems. During assembly, each subsystem has a prescribed mechanical accuracy, electrical accuracy, and optical accuracy that must be maintained. In order to maintain these accuracies prior to and following assembly, every optical system is adjusted to achieve its

optical, mechanical, and electrical accuracy before and after assembly. The process of assembling each subsystem into a photolithography system includes assembly of the mechanical interface, electrical circuits and air pressure plumbing connections between each subsystem. Once fully assembled and the accuracies of each subsystem have been verified, the accuracy of the system as a whole is checked and verified. Preferably, assembly and accuracy analysis should occur in a clean room where temperature and possible contamination can be tightly controlled.

To manufacturer a semiconductor device using the photolithography system of the present invention, the device's function and performance criteria must first be established. Based on these criteria, a mask (reticle) is designed and a wafer is made from a silicon material. Finally, the reticle pattern is exposed on the wafer and, thereafter, the semiconductor device is assembled. Those skilled in the art will recognize that the final assembly of a semiconductor device includes such steps as dicing, bonding, and packaging. The completed semiconductor device is then inspected to ensure that it meets the original perfomance and function criteria as well as any quality control criteria.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above constructions and methods without departing from the scope of the invention, it is intended that all matter contained in the above description and shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.